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Article

Computer Assisted Instruction: Current Trends and Critical Issues

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The use of computers to assist in the learning situation in a simulation, game, tutorial, or drill and practice mode is reviewed on an international basis with centers of activity identified in the United States, Canada, the United Kingdom, and Japan. The use of the computer as an adjunct to support learning is compared to its use in a substitution mode. Evaluative studies of CAI are reviewed and costs are examined. The critical issues of CAI are enumerated and analyzed as they pertain to computer hardware, CAI languages, and courseware development and use. The future of CAI is briefly sketched from the viewpoints of individuals prominent in the field. Finally, conclusions are drawn and recommendations are offered to help ensure the most educationally cost-effective use of CAI in learning situations.

Key Words and Phrases: computer assisted instruction, education, instructional computing

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1. Introduction

The focus of this paper is upon the learning situation and upon the use of the computer to provide course content instruction in the form of simulations, games, tutorials, and drill and practice. In the United States this has come to be known as computer assisted instruction (CAI), and in the United Kingdom and elsewhere as computer assisted learning (CAL). Throughout this paper the term CAI should be considered synonomous with CAL.

1.1 Types of CAI

There are several types of CAI, representing distinctions which have been neglected in the CAI literature and in practice. These types are emphasized throughout this paper. The first relates to CAI which supplements the learning situation, as opposed to that which substitutes for other modes of instruction. The former will be referred to as adjunct CAI [35]. It is illustrated by the short (one-half to one hour) CAI programs available through vendor libraries which are used to support or illustrate concepts. These concepts are then usually discussed in the regular classroom.

In contrast, CAI materials which provide instruction of a substitute or stand-alone variety are usually of longer duration and are generally less well-known and understood in the educational world. These will be referred to as primary CAI. This approach is represented in the United States by the development of entire credit courses. In the United Kingdom the Open University is experimenting with this type of CAI (as well as with the adjunct type). In many discussions worldwide, primary CAI is being debated as a part of distance learning—a term used in many countries to describe efforts to provide education to large groups over broad distances. Distance learning typically encompasses many types of educational technology, including radio, TV, electronic conferencing and mail, and computers, in conjunction with the more traditional methods such as correspondence courses [32].

A second distinction refers to the simplicity-complexity level of CAI. The author approach, employing an easy-to-learn programming language as well as minimal hardware to support the use of the programs, epitomizes the simplistic approach. However, such simplistic CAI produces limited results; i.e., graphics capabilities, large-scale calculations, and the like are not components of such programs. Conversely, complex CAI, which permits extensive use of graphics, large-scale calculations, authoring aids, etc., requires complex author languages (necessitating extensive time for authors to acquire proficiency in use) and large-scale computing capability to support such use.

1.2 Advantages and Disadvantages of CAI

Perhaps the most widely accepted value of CAI is that it involves the individual actively in the learning process. It is impossible for the student to be a totally passive member of the situation, and this very activity and involvement facilitate learning [41]. Another much touted value is the ability of the learner to proceed at his own pace, which has strong implications for both the slow learner and the gifted person.

Reinforcement of learning in such situations is immediate and systematized, which should result in more effective learning, according to established theories of instruction. In addition, the computer in a simulation mode permits students to explore time and space, to mix explosive chemicals together in a simulated laboratory without destroying themselves and the lab, and to investigate complex problems using instruments and methodology which would be excessively costly or not possible at all without the computer.

In addition, the use of computers in this manner frees faculty members or training coordinators to devote more time to the personal, human considerations of their students. Time thus spent with students has been found in a nationwide study of university faculty and students [18] to be *the* most important factor, in students' opinions, in the development of their creative abilities. Thus the use of the computer in these modes should result in an educational environment in which individuals learn more and in which their potential for innovative and creative professional work is more fully developed. Similarly, there should be a greater acceptance of the computer as a helpful tool after the student has used simulations, games, or tutorials.

A final comment regarding the benefits of CAI relates to remedial education. The problems of handling remedial training for students have increased, because the problems of bilingual and disadvantaged students and the inadequate English and mathematics skills of entering university students are being recognized. Computer tutorials, especially in these areas, appear to be both educationally sound and reasonable in cost, if approached in an appropriate manner. Similar cases can be made for the use of CAI to support continuing education and in industrial training programs.

The disadvantages of using CAI in the learning process can be divided into three main categories. In order of importance, these are: (1) the need for teachers and training directors to move from accepted methods that work to a new and relatively untried method in which most individuals have little expertise and which arouses considerable fear and antipathy owing to its heavy technological base; (2) the primitive state of the art, in which a diversity of computing hardware and CAI languages compete with little apparent coordination from professionals in the educational world; in which the majority of available CAI course materials are poorly constructed, largely undocumented, and able to be run on only select computers for which they were written; and in which there are relatively few "experts" to whom CAI users can turn for assistance; and (3) the cost of hardware, CAI course materials (courseware), and individuals to help implement the process—especially since computer vendors initially touted CAI as an ultimate cost saving device. When used as a substitute or replacement method for learning, CAI can be cost saving; however, in actuality CAI is used today mainly as a supplement to enrich learning in the educational scene, and therefore costs should be considered as add-ons.

1.3 Early Developments

CAI usage was initiated in the United States in the late '50s and early '60s. Early work was done at Florida State University, Dartmouth, and Stanford.

At Florida State, using an IBM 1500 interactive computer and the newly developed high-level CAI language Coursewriter, several entire university level courses (physics and statistics) were developed and offered for credit. Providing a quite different viewpoint, but occurring in the same general time frame, the Basic language was developed and implemented throughout the campus at Dartmouth. Thus for the first time faculty and students were provided with a simplified programming language which could be learned in a few days and which permitted the development of simplistic CAI programs.

At Stanford in the mid-sixties, Patrick Suppes and Richard Atkinson [65] applied CAI methodology in a different area. Their work represented the first attempt to increase children's skill levels in basic English and mathematics through computerized drill and practice.

1.4 Scope of the Paper

With this brief orientation to CAI the authors will first survey current CAI trends and existing centers of activity. This will be followed by a discussion of those studies which have attempted to evaluate the use of CAI in special learning situations. Next, costs will be discussed, and the critical issues in CAI will be highlighted, in order to identify courses of action to alleviate some of these problems. The possible future uses of CAI will then be briefly outlined. The paper will close with conclusions and recommendations.

2. Current Trends and Existing Centers of Activity

The majority of work in CAI appears to be concentrated in four major areas: the United States, the United Kingdom, Canada, and Japan. Although some discussion of CAI throughout the world will follow, the major thrust will be in identifying activities in these four countries.

2.1 The United States

Dartmouth University served as one of the prime sources for adjunct CAI program development for many years. During the early '70s Dartmouth, in conjunction with the Universities of Oregon, North Carolina, Iowa, and Texas, formed a consortium (CONDUIT) to acquire, evaluate, and distribute quality instructional computing materials on a national basis. CONDUIT, supported by the National Science Foundation and the Fund for the Improvement of Post-Secondary Education, is located on the University of Iowa campus, under the direction of James Johnson. It currently offers more than seventy-five computer programs in a variety of fields to support higher education classes [20]. Some CAI programs, mostly in Basic or Fortran, are available both for mini- and larger computers, with a few now available for microcomputers.

A similar effort, but encompassing both pre- and post-secondary education, is ongoing at the Minnesota Educational Computing Consortium at Lauderdale, Minnesota, with Kenneth Brumbough as Director of Instructional Services. One of the major recent accomplishments of this consortium is an extensive comparison of the capabilities and costs of microcomputers and their uses in the educational environment [44]. One result of their study has been the installation of several hundred Apple II microcomputers throughout the state of Minnesota, with an accompanying growth in the development of CAI programs.

Another project emphasizing adjunct CAI programs in Basic that will function on most computers is housed at California State University, Fresno, under the direction of Jack Chambers. This project is concerned with the acquisition, faculty evaluation, restructuring, and sharing of quality CAI materials. Over 135 programs are now available in a diversity of fields for both secondary and higher education. Copies of the library have been requested and distributed to over 125 educational institutions worldwide [1].

Yet another California project is housed at the University of California, Irvine, under the direction of Alfred Bork. This project has been underway for a number of years and has produced a significant amount of courseware of a fairly complex nature supporting instruction in physics at the higher education level.

At Stanford CAI work continues under the direction of Patrick Suppes. Entire CAI courses are now offered in Russian and mathematics.

The PLATO system, funded by the National Science Foundation and housed at the University of Illinois under the direction of Donald Bitzer, is probably the most well-known CAI project in the world and therefore will not be dealt with in any great depth here. This sytem uses the Tutor language, a much higher level language than Basic, and requires large-scale computing capability, at least for authoring purposes. Despite this, the system has been extensively used as supplemental to the learning situation. Since the system can produce complex CAI programs having graphics capabilities (including animation), voice output, and the like, it is quite possible that the system will be used even more heavily in the future in the primary CAI mode.

A second major PLATO installation, emphasizing support for music education, is located at the University of Delaware. A third is centered at Florida State University at Tallahassee. At this installation support is provided to select Florida high schools for PLATO-based remedial studies in mathematics. Other, smaller PLATO installations are scattered throughout the United States.

A final project of interest, emphasizing the use of primary CAI, is represented by the TICCIT (Time-Shared Interactive Computer-Controlled Information Television) project. Funded by the National Science Foundation through a grant to the MITRE Corporation, TICCIT was developed at the University of Texas and Brigham Young University under the direction of Victor Bunderson. Using minicomputers and modified TV receivers, the system was designed to provide basic undergraduate instruction in English and mathematics. It was initially implemented at Phoenix College (Arizona) and the Alexandria Community College (Virginia). The English portion is still in use at Phoenix [45], and both the English and mathematics courses are still in use at Alexandria [59].

2.2 The United Kingdom

Computer assisted learning (CAL), as CAI is known in the United Kingdom, began in the late '60s in scattered but important projects headed by Peter Smith at Queen Mary College, Robert Lewis at Chelsea (both part of the University of London), and James Howe at the Artificial Intelligence Laboratory at the University of Edinburgh. The British government began to be seriously interested in this type of activity at about this time. This interest resulted in funded work at Leeds and, in 1972, in a two-million-pound, five-year CAI project. With Richard Hooper as director, the program began in 1973 as the National Development Program in Computer Assisted Learning (NDPCAL) [31].

The NDPCAL project was primarily concerned with stimulating CAI through development of new courseware and was essentially based on work already underway. Thus Leeds University became the base for projects in chemistry and statistics, Queen Mary College for the engineering sciences project, while the University College and Chelsea College, both of the University of London, combined with the University of Surrey to develop materials in support of undergraduate education in the sciences. This latter project became known as Computers in the Undergraduate Science Curriculum (CUSC).

The NDPCAL project was completed in 1978, and government funding in the United Kingdom is currently at a minor level. However, the project did result in a number of ongoing centers dedicated to the improvement of instruction (with emphasis on CAI) at a number of universities. The authors of this paper visited several of the United Kingdom campuses in late 1979 and found CAI activities to be flourishing, especially at Chelsea College, University College, and Queen Mary College of the University of London; the University of Surrey; and the University of Edinburgh. A significant number of quality CAI programs developed under this project are now in use—between 75 and 100 units from all NDPCAL projects [32]—and exchange programs are now emerging both within the United Kingdom and between United Kingdom and United States institutions. A particularly strong exchange program is housed at Imperial College under the direction of Nicholas Rushby [57]. In addition, enthusiasm runs high and initial work appears most promising at a number of other United Kingdom institutions, especially Anthony Hoare and Frank Pettit's laboratory at Oxford [56].

In addition to the NDPCAL project, the British Open University (OU), which opened in 1969 to criticism, is by most accounts now considered highly successful [47]. The OU is now using the computer in a CAI mode. Although the authors of this paper visited the main campus of the Open University, the extent to which CAI is now in use in the OU is not totally clear. It is apparent, however, that current usage is expected to increase both in the CAI adjunct and primary modes.

Another CAI-related activity currently in the research and experimentation stage in the United Kingdom is Viewdata. This is a computer-based information and communications medium under development by the Post Office. The intent is to provide an interactive nationwide service to the general public and professional community. It will operate via terminals based on TV receivers, the regular dial-up telephone network, and a set of interconnecting computers and databases [26].

2.3 Other Activity Worldwide

Canada and Japan both have shown strong interests in CAI and have developed centers of activity. Major Canadian centers include the Ontario Institute for Studies in Education, the National Research Council of Canada, Queen's University, Concordia University, and the Universities of Alberta and Calgary [32].

In Japan, experimentation with CAI is in progress at the university and the secondary school level, as well as in industry. Research studies in CAI have been conducted by the Nippon Telegraph and Telephone Corporation, the Japanese Society for the Promotion of Machine Industry, and by scholars at such institutions as Osaka University, Hokkaido University of Education, Aschi University of Education, and others. Research on CAI at the secondary school level is proceeding under the auspices of the National Institute for Educational Research [59].

With the exception of Russia, in which minor CAI activities have been reported [58], the authors are unaware, either through personal experience or the literature, of major CAI activities elsewhere in the world [32]. However, the developing nations, especially India and those of South America and Africa, faced with problems of large numbers of persons spread across thousands of miles, limited funds, and the desire to provide a reasonable education for everyone, are experimenting with distance education. Although their initial attempts are concentrating on radio and TV, they have also begun to look to the British Open University as a model. Thus, as the Open University develops CAI materials and uses them both successfully and financially, the widespread use of CAI for distance learning, particularly of the primary CAI type, can be anticipated [8, 17, 21, 27, 48].

3. Evaluations of CAI Effectiveness

The effectiveness of CAI has been defined differently by different investigators. To some effectiveness means the amount of learning that takes place initially. To others it means the degree of retention of learning, or at the very least, whether or not an individual stays in or drops out of a learning experience. Still others are concerned with the learner's change in attitude toward the computer as an instructional medium or simply as a helpful tool in the culture. Finally, owing to the fact that CAI is in its infancy, some are simply concerned with transportability of materials and/or acceptance of the materials for use by others.

In general, well-designed, tightly controlled evaluative studies of the use of CAI are rare. Some have been conducted by this time, however, and trends are becoming discernible. Several of the more prominent studies will therefore be reviewed, followed by a summary of the bulk of the others.

The CAI physics course developed at the Florida State University is in the form of a computer tutorial. Tentative evaluations indicate that instructional time was reduced by 17 percent over the traditional lecture course, and students scored higher on final exams and attained superior conceptual mastery [37].

The medical school of the University of Southern California has used computer-controlled modeling to teach anesthesiology. A lifelike model exhibits a variety of human responses, allowing the student to test his knowledge of anesthesiology. Evaluations using experimental and control groups demonstrated that when the model was used, fewer trials over a shorter period of time were required for students to reach an acceptable level of professional performance [37].

Studies of the CAI Russian course at Stanford, using experimental and control groups, revealed positive results in terms of student performance on examinations, student behavior, and student responses to a questionnaire about the program. Students taking the computer-based course scored "significantly better" on the final exams. In addition, far fewer students dropped out of the computer-based course [37].

Probably the most significant uses of the computer in simulation, game, or tutorial modes are represented by the Chicago City Schools Project (using Suppes and Atkinson's materials), the PLATO project, and the TICCIT project.

The Chicago City Schools Project was begun in 1971 and is continuing today. It affects over 12,000 fourth through eighth grade children in the inner city schools, with 850 terminals providing tutorial lessons in mathematics and reading. Originally designed to improve skills in these areas, the project has had significant results. As an example, the average increase in reading ability in the schools was 5.4 months per pupil for each 10 months of regular classroom instruction. Using the computer tutorial approach, the average rose to 9.0 months improvement for 8 months of instruction [55]. This program is now being formally evaluated by the Educational Testing Service under a grant from the National Institute of Education [64].

Both PLATO and TICCIT have recently been evaluated in a controlled, systematic manner by the Educational Testing Service [2, 46]. Donald Alderman of ETS commented in regard to the outcome of these evaluations as follows:

> The PLATO evaluation covered five fields: accounting, biology, chemistry, English, and mathematics. Computer uses in these fields represented supplemental or replacement instruction for regular classroom work—in no cases were these PLATO programs in lieu of entire courses.
>
> The PLATO materials were used and evaluated at five community colleges; four were a part of the City Colleges of Chicago, the fifth was in Urbana, Illinois.
>
> On the positive side, a large number of students and faculty became involved in the use of these materials, and students' attitudes toward PLATO-type materials did improve. Additionally, a significant positive achievement effect was found for PLATO vs. traditional classroom procedures in the area of mathematics. No further significant achievement effects were found for any other subjects, either in favor of PLATO or in favor of the regular classroom.
>
> The TICCIT evaluation concerned both of the mathematics and English courses in use at Phoenix College and the Alexandria (VA) Community College. These two applications represented entire courses, although *the English TICCIT program included much more personal interaction between students and faculty than did the mathematics course.*
>
> The results of the mathematics evaluation, comparing TICCIT courses to the regular classroom, and adjusting for entrance ability of students, indicated a significant achievement effect of TICCIT over the regular classroom, although fewer TICCIT students completed the course within the semester than did those in the regular classroom. Additionally, more students had favorable attitudes toward the lecture classes than toward the TICCIT approach, although there did not appear to be any changes in overall attitudes toward additional learning in mathematics.
>
> The results of the English evaluation also indicated a significant achievement effect in favor of the TICCIT approach, and in this situation, the completion rate for TICCIT was the same as for the classroom. Additionally, there were no significant attitude differences in favor of either approach.
>
> ETS' responsibility in this regard was to evaluate the educational aspects of PLATO and TICCIT, and therefore no cost comparisons are available [3].

Does the above mean that such uses of the computer are effective? Certainly those who have become involved with the projects already mentioned would answer that question in the affirmative. Many who have studied the subject from a more objective vantage point also agree.

Overall, a review of the literature revealed the following consistencies:

(1) *The use of CAI either improved learning or showed no differences when compared to the traditional classroom approach* [2, 24, 35, 42, 46, 54, 62, 66].

(2) *The use of CAI reduced learning time when compared to the regular classroom* [15, 24, 35, 42, 60, 62, 66].

(3) *The use of CAI improved student attitudes toward the use of computers in the learning situation* [15, 35, 42, 46, 62, 66].

(4) *The development of CAI courseware following specified guidelines can result in portability and their acceptance and use by other faculty* [1, 20, 36, 41].

There are also some indications that low aptitude students profit more from the use of CAI than either average or high aptitude students [24, 66], and that retention rates may be lower than for traditional means [62].

The studies reviewed thus have shown striking consistencies in results, even though the type of CAI mode used (tutorials, drill and practice, games, simulations) has varied and the learners concerned have ranged from elementary school children through adults in training programs. One factor has remained relatively constant, however. The bulk of the studies have concerned the use of adjunct CAI, in which a classroom teacher is, at the least, available for consultation as needed. In the one major situation of primary CAI in which entire mathematics and English courses were taught through the TICCIT system and evaluated in a controlled manner, completion rates for the mathematics course dropped considerably below the traditional classroom, and student attitudes toward the CAI mathematics course were not positive. The opposite was true for the English course, as indicated earlier. The apparent cause of these discrepant findings was the more significant involvement of the English faculty with the students in the CAI English course, as compared to the limited involvement of the mathematics faculty with students in the mathematics CAI course. Thus, by implication, primary CAI, and distance learning in general, may achieve results similar to those for adjunct CAI as long as there is sufficient human interaction accompanying the use of the CAI materials. The Open University is currently researching this problem to determine the optimum level of human interaction necessary to produce the most effective results for various learning situations [51].

4. Costs

Costs account to a significant extent for the lack of use of CAI in learning situations, especially at the elementary/secondary level. As Kearsley [35] has pointed out, although CAI may be perceived as instructionally effective, educators may be reluctant to utilize it if it is perceived as being prohibitively expensive.

The accepted method for assessing CAI costs is to total all expenses for computing hardware, software, telecommunications, courseware, and implementation, and then divide by the total number of student hours used. However, in actual practice, many so-called "hidden" costs are seldom entered into the equation [6]. For example, terminals and line costs are frequently considered user costs and are omitted from the calculation. Similarly, space costs, heat, electricity, etc., are often paid by the educational institution directly and thus are not considered. Also, the life-span of courseware is seldom considered, and implementation costs (staff to develop teaching guides for use of the programs, etc.) are often ignored. Compounding this situation, educators, who have been the major developers of CAI, are seldom good accountants, and thus data as to actual time taken to develop courseware often is reported inconsistently. Cost estimates for CAI, for example, are highly variable. Only recently have patterns been emerging which permit comparison of costs for complex CAI on very large computers with more simplistic programs running on mini- or microcomputers.

Other than hardware costs (which are rapidly diminishing), the cost of developing CAI courseware appears to be the greatest single factor of concern. Various authorities report courseware development time ranging from 50 to 500 hours of preparation to produce one hour of student CAI contact time at a terminal. One hundred hours appears to be the most widely accepted rule of thumb [7, 42, 49, 64]. The key variables appear to be the complexity of the programs produced and the expertise of the individuals involved. Costs per student hour of programs developed to date range from \$.50 to \$28.50 [41, 52, 61, 64, 67].

In addition to development costs, other factors in the equation must be considered. Materials running on microcomputers have been reported to have the lowest costs. Similarly, the greater numbers of students using the materials, the lower the per-student-hour cost reported. Thus the CUSC programs in the United Kingdom show the highest costs (apparently due to low usage). CAI programs running on microcomputers at the Highline School District in Seattle [61] and those used by large numbers of students in the Philadelphia schools [64] show some of the lowest costs. Thus, in addition to using inexpensive hardware, one major way to lower costs is to share courseware.

Norris [50] has pointed out another appropriate factor quite often overlooked in cost studies of CAI, i.e., that traditional instructional costs have been increasing at the rate of 13 percent per year for the past three years, while CAI costs have been decreasing at 5 percent per year, coupled with a 10 percent improvement in performance. Therefore the cost avoidance aspect of CAI should also be considered.

Finally, as McKenzie [41] has pointed out, if our goals are to improve the learning situation, then costs must be set beside a qualitative assessment of educational change to answer the question: Is it worth the cost?

5. The Critical Issues

The critical issues in CAI today relate to computer hardware, CAI languages, courseware development and sharing, and courseware implementation. Again, the major concern is with the effects of these variables upon improvements in the learning situation in relation to the costs involved.

5.1 Computer Hardware

At the current time the availability of microcomputers with their multisensory capabilities and low costs appears to be the technological breakthrough which may well result in significant increases in CAI usage at all educational levels. Eisele [25] feels that an entire new era of educational application is at hand. Critchfield [22] predicts that within the next ten years all educational institutions will have one or more microcomputers, while Matthews [43] points out that in time microcomputers may become more commonplace in schools than some audio-visual devices.

A major advantage of microcomputers is their low cost. A \$3,000 investment is currently sufficient for a configuration capable of providing adequate support for CAI. In addition to providing similar capabilities to minicomputers, however, some microcomputers also permit voice input and output, color displays, high resolution graphics, and text editing. Video disk enhancements at reasonable costs appear imminent [38]. Microcomputers are essentially portable and require minimal maintenance. Their disadvantages are in the areas of file handling techniques, processor capabilities, and disk capacity. Thus their strengths lie in their use for instruction in computer languages such as Basic, applicability for production of novel and innovative CAI materials, etc., while a significant weakness is in their handling of standard administrative data processing applications. In this latter regard, although agreeing that microcomputers will likely be prominent shortly on the high school scene, Blaschke [10] has pointed out that a survey of secondary and elementary principals indicated that financial resources for purchases of microcomputers would be more readily available were the microcomputers able to serve the dual purpose of supporting both instruction and administration.

The advent of the microcomputer has resulted in heated debates concerning the relative merits of CAI systems supported by large-scale, powerful computing configurations as contrasted to the CAI capabilities of the microcomputers. Bitzer has amply championed the cause of the large-scale CAI systems such as PLATO, while Bork has spoken strongly in favor of the microcomputer approach. Both have recently softened their stances, however—Bitzer by developing the means whereby PLATO materials may be downloaded and run on a microcomputer, although still requiring the large computing capability for authoring [64]. Bork, conversely, seeing the need for students to communicate with one another, now envisions the possibility of a distributed environment, especially for development [12].

Returning once more to the topic of adjunct CAI and primary CAI, it would appear that microcomputers may well provide both the adequate technology and the low cost which, in a distributed network environment, will permit wide-scale use for both types of CAI worldwide. This seems especially likely if microcomputer cost/performance ratios continue to improve as predicted.

Licklider [38], for example, has estimated that by 1988, owing to technological advances, $500 worth of computing equipment could provide a 1-microsecond, 32-bit machine with 32,000 words of fast memory plus console or secondary memory. This type of equipment, with satellite communication in a distributed environment, and with the central machine used for authoring and communications, might well support the type of distance learning envisioned by the Open University.

+ OUR IBM 370/155 is 4 32 BIT MACHINE

5.2 CAI Languages

CAI languages developed specifically for high-level, complex, interactive use include Coursewriter, developed by IBM; Tutor, developed for PLATO and now marketed by Control Data Corporation; ASET (Author System for Education and Training), developed and marketed by UNIVAC; and CAN, developed and marketed by the Ontario Institute for Studies in Education. All systems provide authoring aids, calculation capabilities, and varying levels of graphics commands. However, they are all machine dependent except CAN, which will function on computers from several major vendors and which is now being prepared for use on a microcomputer [53].

In a different vein, a number of other languages have been used extensively for CAI, owing to some extent to the ease of learning to use them (although they do not have CAI authoring aids). These languages include Basic, APL, Fortran, and Pascal. Each has unique features which appeal to different authors. It is interesting to note that Kearsley [34] in a study of CAI languages found that the emphasis shifted from the use of Coursewriter and Tutor in 1970, to APL, Tutor, and Basic in 1976. Since Basic is the predominant microcomputer language, it is likely to continue to gain in usage for CAI development.

The critical issue indicated in the above, however, is that there is no standard, high-level, complex CAI language which is machine independent, and which combines authoring aids, calculational mode, and graphics capabilities. This is currently one of the major impediments to the widespread use of CAI to support the learning process. Although the possibility of language independence (i.e., the ability to translate automatically from one language to another and thus to achieve portability) has been discussed for some time, such software is not now available.

5.3 Courseware Development and Sharing

The single most critical issue in CAI today is the development and sharing of quality CAI materials. The majority of CAI courseware currently available is of the adjunct type, developed by individual faculty members for specific purposes. It has largely been written in a machine dependent language and is undocumented. Thus the available courseware is difficult to share and, in many cases, protected by copyright if of significant value. In "The ABC's of CAI" project [1] over 4,000 CAI programs written in Basic were reviewed, and about 3–4 percent were found acceptable by faculty in the fields concerned. To permit sharing of these programs, restricted Basic standards had to be developed and programs restructured at an average cost of 100 hours per program.

In regard to authoring, the authors are in agreement with Alfred Bork that "The notion that computer-based materials can be produced by anybody, completely by themselves, is an archaic concept" [11, p. 20]. This concept has also been reiterated by Dean [23], who believes the team approach, using at least three faculty members, a programmer, and an instructional designer, has the best chance of developing courseware of high caliber which will be acceptable to the greatest number of faculty and students. Howe and du Boulay [33], although not arguing for or against teams, do caution that we not repeat our previous mistakes, and they point out that learning principles should be recognized in the development of future CAI programs.

The team approach and specific learning strategies were used in the preparation of TICCIT materials, while a more singular faculty member approach was used with the PLATO system. As indicated earlier, although student attitudes were generally more favorable toward PLATO, the most significant learning gains over the traditional classroom approach occurred with TICCIT.

Perhaps a more basic question than the individual versus team approach to development, however, centers around the question of faculty motivation to develop and share materials. Both Hawkins [29] and Sprecher and Chambers [63], in broad-based studies, found that direct financial reward was not a primary motivator. Rather, the traditional rewards for the scholarly life appeared to be the goals. Thus, recognition and acceptance by one's peers for courseware development and sharing of such materials, release time, and acceptance of courseware development by peers and by administrators as equivalent to research publications for promotion and tenure, appeared important as means to resolve the incentive question.

5.4 Courseware Implementation

Until recently, those concerned with facilitating the use of computers in the curriculum were content to offer seminars on "How to Program," and the like. With the probability of widespread CAI usage at all educational levels, however, a great deal more attention will need to be paid to the question of how best to integrate the CAI materials into the curriculum. Otherwise, as preliminary data indicate, CAI materials will be used as add-ons, with little regard to their effectiveness in the total learning environment.

The CUSC staff at the University of Surrey identified courseware transfer and implementation as major goals of the British NDPCAL project. To achieve these goals, the programs were developed by teams from two or more educational institutions. The programs were all student-tested a number of times, and written student guides were prepared for use with each CAI package.

Although transfer goals were realized, *the ability* to rewrite student guides effectively had to be transferred since faculty tended to reject the original student guides which accompanied the transfer of the programs. The transfer was achieved by including in the documentation copies of all student guides that had been developed and thoroughly tested. In addition, a teacher's guide was also included which outlined the rationale behind the guides, as well as possible uses of the computer program.

Thus, in regard to both adjunct and primary CAI, some type of personal support and written materials from teacher, advisor, etc., appears necessary in order to achieve maximal benefits. Decisions will be required, especially in regard to primary CAI and distance learning, as to the frequency and amount of personal contact and supporting materials which most facilitate learning in these situations.

6. The Future of CAI

6.1 Early Predictions

In the early '70s several studies were made of the future educational technology in general, and CAI in particular, with 1980 to 2000 as the target prediction dates. The most well-known of these studies was published by the Carnegie Commission [16]. In this study the Commission predicted both widespread acceptance of educational technology by 1980 and the availability of a large quantity of quality courseware. Further, they predicted that by that time, new [illegible] engaged in creating and developing instructional materials on the nation's campuses would have emerged. As indicated throughout this paper, however, widespread acceptance and use of CAI has not yet occurred.

Two other studies also independently predicted significant increases in the use of CAI in higher education. The first used community college representatives and persons from computer-related industries active in CAI (40). The other study was based on faculty response from the nineteen-campus California State University and Colleges [4]. The Luskin study [40] predicted that the major obstacles to the use of CAI would be resolved by 1987, resulting in general acceptance and use of CAI in higher education by that time. Ames in turn [4] found the CSUC faculty predicting a 270 percent increase in CAI usage from 1976 to 1980. Although the accuracy of the Luskin study predictions cannot yet be assessed, personal observations by the authors of the use of CAI within the CSUC system indicates increased usage, but probably not to the extent predicted in the Ames study.

6.2 Predictions, 1980 to 1990

Resulting in part from the failure of current usage to match past predictions, predictions of the future of CAI have become guardedly optimistic. Most writers agree that technological (hardware) barriers are largely resolved or will be in the very near future, and further, that cost reductions due to mass production and consumption for home entertainment and learning will permit cost-effective uses of CAI in both the traditional classroom and in other settings [5, 9, 13, 14, 30, 38, 50]. This cost-effective technology will include large-scale mini- and microcomputers with voice input and output, interactive television, video disk systems, and satellite communication.

There is also general agreement that computers linked with video disks on the one hand, or communication satellites on the other, will play significant roles in nontraditional educational practices resulting in a revolution in courses and learning. Luehrmann [39], for example, sees the use of video disk-based learning materials, purchased or leased outside the usual educational framework and used on the home TV set, as possibly playing a significant role in learning in the future. He sees little change in the United States in the next ten years in regard to the roles played by broadcast or cable TV.

Atkinson [5], Bunderson [14], Hirschbuhl [30], and Norris [50], on the other hand, envision nationally or internationally distributed networks with large, shared databases. The individual could then use video disk materials on stand-alone microcomputers or through the network, access larger databases as needed, communicate with other persons, and the like. Norris spells this out in some detail, envisioning international networks of learning centers with CAI as the main delivery system using video disks, audio input and output, and touch input. He foresees these centers as providing direct learning experiences for individuals or providing sales of developed materials to educational institutions, to industries for training purposes, etc.

Futurists are in most disagreement, however, as to the role CAI will play in traditional educational institutions, especially in situations in which academic credit is granted. As opposed to the views of Luskin [40], Norris [50], Atkinson [5], and others who see CAI as playing major roles in education, both Luerhmann [39] and Charp [19] see matters remaining much the same over the next ten years in the traditional educational setting. Both, however, foresee the increased use of CAI for instruction in the basic skills for areas of reading and mathematics, especially in work not involving academic credit.

Licklider [38] also points out the inherent dangers in the widespread use of technology for education. Chief among these concerns are the possibilities that computers will be used to emphasize facts over concepts and principles, and that they will be used to condition acceptance of political doctrines, dictate personal philosophies, etc. Although most other writers have not dealt with these problems, they are matters of concern if CAI becomes as widespread in its use as predicted.

7. Conclusions and Recommendations

A heavily academic background is drawn upon to offer conclusions as to the currrent state of the art in CAI. Recommendations are made as to profitable courses of action to follow to help achieve the most educationally cost-effective use of CAI.

7.1 Conclusions

(1) The expectations of the early '60s in regard to widespread use of CAI in education by 1980 have not been met. However, with recent advances in cost-effective CAI uses as exemplified through the microcomputer, rapid increases in future CAI use in the learning situation are foreseen.

(2) The greatest number of advances in adjunct CAI have been made in the United States. This trend is likely to continue with increasing usage throughout the United States—both in the traditional educational systems (higher, secondary, and elementary, in that order), and in geographically distributed learning centers.

(3) The greatest number of advances in primary CAI and distance learning have been made in England via the Open University. This trend is predicted to continue throughout at least the first half of the '80s, with CAI usage via satellite spreading to the developing countries.

(4) The private sector in the United States will resolve technological (hardware) problems connected with CAI early in the '80s. By the mid-'80s computers in general, video disks, and satellite communication will be cost-effective for both traditional and home learning.

(5) The problems of compatibility and portability of languages, standard documentation procedures for courseware, etc., will not be resolved by the private sector and therefore must be addressed elsewhere.

(6) The critical issues in the CAI field today which will continue to plague users throughout at least a major part of the '80s relate to the development, evaluation, sharing, and implementation of quality instructional courseware.

7.2 Recommendations

In light of the analyses of the CAI situation worldwide, the authors recommend the following in reference to the use of CAI in the United States.

(1) *A nationwide, standard high-level CAI language should be developed for complex CAI development which incorporates authoring aides, computational capability, graphics capability, multisensory input/output controls, and prescribed documentation standards.*

This approach should build, as much as possible, upon existing frequently used CAI languages, should be as simple to use as possible, and should be capable of running on large, mini-, and microcomputers. Impetus for this development should come from the educational sector, perhaps incorporating a cooperative venture with the private sector. Initial efforts should be funded by the federal government, since such a development would clearly be in the national interest.

CAI authors could then use the language which most meets their needs. Thus, simplistic CAI program development could continue as in the past, with authors using languages such as Basic, APL, etc., while those desiring to develop complex, yet portable, programs could make use of the new standard CAI language.

(2) *Development of quality, creative, transportable CAI materials of the adjunct type should be encouraged.*

Adjunct CAI materials, being mainly of short duration and thus not requiring long-term commitment and extensive funding, can be accomplished by individual faculty or teams of faculty (who have expertise in these activities) supported by assistants to provide programming support. To provide motivation for faculty to engage in these activities, and to provide incentive to identify topics and objectives that are both broad and important to the field, educational institutions are encouraged to look to the established institutional model for rewarding professional accomplishments. Thus, the provision of faculty release time on a competitive basis, recognition by other faculty and administrators that courseware development is an acceptable and laudatory activity, availability of training programs in the area, and acceptance of peer-reviewed and published courseware as equivalents to published research in promotion and tenure decisions, may well help move faculty toward the development of quality creative adjunct CAI materials.

The state and federal governments, in turn, can stimulate such development by funding faculty release time both for courseware development training and for actual time spent developing such materials. In addition, federal funding could be most beneficial for programs designed to change campus attitudes in directions more favorable to courseware development.

Finally, private enterprise could profit through joint arrangements with faculty for the development of CAI materials which could be useful both in the traditional classroom and in nontraditional learning centers, industrial training programs, etc.

(3) *Development of quality, creative, transportable CAI materials of the primary type should be encouraged.*

Since primary CAI materials are usually lengthy, requiring extensive time commitments and heavy funding for development, they could profit from joint ventures by educators, government, and the private sector. The private sector might well take the lead in these ventures; developed materials could be used initially in learning centers, and secondarily in traditional educational settings. As long as educators fill appropriate roles as subject matter and learning theory specialists, and as long as the materials are peer-reviewed and evaluated by faculty and students, the results should be of high quality and should be considered academically respectable.

(4) *Evaluation and sharing of quality courseware should be emphasized.*

Educational consortia, as well as committees within the professional associations of academic disciplines, should be formed to provide peer evaluation, publication, and distribution of CAI materials. In this way, quality courseware will be recognized and distributed, and the necessary professional status will be brought to courseware development so that it will be acceptable as a professional accomplishment in promotion and tenure decisions on the campuses. Again, development in this area should be built upon existing sources; however, additional ones will be needed.

The federal government and the private sector, at this stage, can both profitably play the role of funding agencies for these ventures. Initial efforts, if they are to be acceptable to the academic community (at least in regard to peer evaluation), must come from within its own ranks.

(5) *Appropriate use of CAI materials in the learning situation should be studied and implemented.*

The use of CAI materials to facilitate learning is an entirely different problem from the development, evaluation, and sharing of such materials. Unfortunately, these problems have been intermixed, and this has resulted, at times, in the misuse of CAI materials. To alleviate this condition, educational institutions need to provide release time for their faculties in order that the problem may be researched. On the basis of such studies, courses should be introduced so that students preparing for a teaching career at any level would be provided with a minimal background with which to implement the use of CAI as a learning tool.

Federal and state governments, in turn, should fund such studies as well as release time for the development of courses indicated above.

(6) *Distance learning experiments should be implemented.*

The development of a model for distance learning in the United States might well be a joint venture of the educational sector, private sector, and the federal government. Impetus could come from education, with funding from the private sector and the federal government. The initial model, perhaps organized as a branch campus of a major university or university system with consultation from the Open University, could experiment with primary CAI, satellite communications, microcomputers, level of human interaction required for effective learning, and the like. Although the United States would not be likely to accept one Open University for the entire country, this proposed model could permit in-house development of some of the materials and prototype technological and organizational schema, which could then serve as guidelines for other developments both within the country and internationally.

(7) *Finally, communication of worldwide CAI developments should be enhanced.*

As indicated throughout this paper, although the United States still maintains a leadership role in CAI, important activities are occurring outside the country. At this stage of development, it is particularly important to all concerned that scientific knowledge in this area be communicated worldwide.

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EDP For ABC's

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When 200 of the 538 Walbrook High School seniors failed City of Baltimore mathematics and/or reading proficiency tests mandatory for the first time for graduation, we realized that we needed a quick and effective solution to this problem. We decided to re-educate the students with a concentrated, computer-based skills learning program.

The net result: In 60 days, the PLATO system, as it is called, accomplished what the schools had failed to achieve in 12 years. All but nine seniors passed the mandatory tests.

Although we have used the PLATO system at Walbrook for more than five years, including a small pilot operation, we have only 12 terminals. Many of the seniors who failed the tests previously hadn't had access to the computer-based education system. If we had our "druthers," we would have 100 terminals because a large number of students enter Walbrook High, an inner-city school, with reading and math skills below the sixth-grade level. The staff of just 110 teachers has only three years to work with 2,500 pupils.

Fortunately, though, 90 percent of the students chosen for the PLATO program increase their achievement levels. Youngsters at both ends of the learning spectrum have advanced as many as three grades within a single school year. Because of those results, we apply the PLATO system, developed by Control Data Corporation (CDC), Minneapolis, as much as possible.

More than 200 students currently are taking basic skills, about half of them in mathematics and half in reading. Another 60 are in foreign language classes, and we have a smattering of gifted youngsters taking subjects not usually taught at Walbrook.

Altogether, about 125 children receive PLATO instruction daily, usually spending half of a 50-minute period at a terminal, learning a skill, and the other 25 minutes in a more conventional teacher-classroom session, learning how to apply the skills.

Our staff recommends students for the PLATO program; department heads give approval. Seniors needing remediation have priority. Based on information from a pre-test taken by a child at a terminal, the PLATO computer in Minneapolis then suggests where the student should be placed in the curriculum and which instructional material should be utilized. A youngster usually spends one semester on the system.

Getting students to use the terminals is no problem. They are at them at the beginning of the day; we have to chase them away in the afternoon; and they would come in on Saturdays if the school were open. During a recent break-in, vandals extenively damaged Walbrook High. Significantly, the PLATO terminals were untouched.

Moreover, some parents have moved into the Walbrook district so their children, both who are gifted and those needing remediation could take advantage of the PLATO sytem.

Computer-based education is just one of several approaches we use to motivate our children. But it is one of the most effective because the PLATO terminals provide an individualized, self-paced training environment in which the student competes only against himself or herself, eliminating unnecessary peer pressure and embarrassment. This defuses the hostility found in a child who has experienced a lack of success in the past and anticipates a lack of it in the future.

Each unit within the PLATO Basic Skills curriculum has one or more objectives which the student must master before he or she can move on to another unit. The beginning units have several simple objectives; as the student progresses, the objectives become more complex. However, the student may repeat all activities in a unit as many times as necessary to master a given objective. And no one, not even other students working at terminals alongside, is aware of how long it takes.

By presenting material in small increments, the PLATO method enables the student to build a history of successes. It encourages him with immediate feedback, impossible in a convention classroom system. This reinforces and supports the successes and motivates the student to work harder because he sees that he can learn. By contrast, the conventional learning approach may take so long that the child is turned off and quits trying.

Student interest remains high while the child receives PLATO instruction, giving thanks, in part, to course content, dynamic, animated cartoon displays and to the "interactive" nature of the presentation. The students respond by simply touching the terminal's screen or keying-in data. They can even choose paths of instruction, thereby gaining greater control of their on learning environments.

As the youngster's successes move him on to more complex subject matter, he continually is encouraged by the system's displayed comments. "Superior work, Charles," the screen may flash, or "Terrific," "Right on." And if the student makes a mistake, the system tells him gently, "Let's try again, Charles," and

Terminals inspire children to learn by interacting with them in a positive or gentle manner.

gives a hint to help him along.

The PLATO sytem provides the type of individual remediation that most teachers in typical classroom situations simply cannot give. It stores data on each student's progress, which allows the teacher to evaluate the child's efforts.

For example, if a youngster is spending too much time on the tutorial aspects, the teacher can surmise that he or she is having a problem determining the task or interpreting the reading matter, which requires only a third-grade reading level. At that point, the teacher will spend more time with the student. With half of the average basic skills class on the terminals at any one time, the teacher has more time to work with students.

PLATO's purpose is to assist our staff, not replace it. In fact, without PLATO computer-based education, we's have lost our entire Latin program due to budget cuts. One teacher, Mrs. Nicole Harryman, instructs both French and Latin with the aid of the system and has written programs for it, mostly vocabulary for translations. Similarly, Melvin Lee Johnson, a mathematics teacher, has developed a consumer mathematics lesson, entitled "100 Basic Math Facts," which is a time drill with answers for sets of problems in addition, subtraction, multiplication and division.

Our other mathematics teacher, Robert J. Wise, helped CDC with some of the Basic Skills programming. However, the Basic Skills Learning System was designed and developed primarily by a group of educators directed by Dr. Peter Rizza, an educational consultant to Control Data Corporation.

The Basic Mathematics Skills course includes number concepts; arithmetic operations involving numbers, fractions and decimals; and special applications topics involving ratio, proportion, percent, geometry and measurement. The Basic Reading Skills course includes fundamentals of word structure; fundamental vocabulary development; and basic comprehensive skills. Also available, but not currently used at Walbrook, is a Basic Language Skills cours which includes language structure and word usage; sentence and paragraph structure; and mechanics and conventions in writing.

Personally, we favor the City of Baltimore's basic skills examinations. We want our students to be well-equipped, whether they go out into the world of work or on to college as 60 percent of them do — a figure 20 to 30 percent higher than the national average for public high school graduates. Basic skills are important to these youths so that the colleges don't become "revolving doors" for them. We want our students to stay there and succeed, notsjust be taken in to meet a "black quota," and then disappear after a semester or two.

We offer four curricula at Walbrook: college prep, job prep, honors and experience-based career education. We also offer 14 majors. Every child has one and must complete a certain sequence of courses, totaling 24 Carnegie Units, to receive a major's diploma, as more than 50 percent of our students do.

The State of Maryland requires only 20 Carnegie Units to graduate.

The PLATO system has benefited honors students, who can use the terminals unsupervised to expand their opportunities in higher mathematics, science and foreign languages. For instance, one gifted student studies trigonometry, not usually offerd at Walbrook, via the terminals. He is now doing mathematics at the college level and has been accepted at Massachusetts Institute of Technology.

Our career education curriculum has proven to be an effective motivator, too. It offers specialized programs that help the child learn decision-making, career exploration and career choice in fields such as communications, arts, dance, drama and music. On the fourth Sunday each month we have a career seminar in which the students meet leaders from government, education and business.

Many of our social activities also encourage academic progress. Typically, all honor roll students get a free evening at the most popular disco in town. And our students make extensive trips, some to Europe. These are available to

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Government Action Line

Direct-Access Reader Service To Government Suppliers

***Government Action Line** is a listing of companies offering equipment, services, and supplies specifically designed for the government information technology environment. For additional information such as price, delivery and product specifications, consult the listing, contact the firm and mention that you found them in **Government Data Systems**.*

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Bonnockburn, IL 60015
Checkmate Remittance Processing System
Contact: Morris Frydman 312/948-8250

Chromatics Inc.
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Atlanta, GA 30340
Color Graphic Computers
Contact: Donald K. McKinney
404/447-8797

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OASIS Mass Appraisal Systems
Contact: David Moreton
305/646-1144

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Austin, TX. 78753
HIPLOT — family of digital plotters.
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Lexitron Corporation
9600 DeSotto Ave.
Chatsworth CA 91311
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Contact: Marcia Powell 213/882-5040

Litton Computer Services
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Reston, VA 22090
Computer Services
Contact: James Harrington,
703/471-9200

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Woodside, NY 11377
Microfilm jacket file system
Contact: Ed Keane 212/672-9000

Paradyne Corporation
P.O. Box 1347
Largo, FL 33540
Pixnet Communications Network
Contact: Evelyn MacDonald,
Govt. Mgr. 813/536-4771

Tektronix, Inc.
P.O. Box 500
Beaverton, OR 97077
Computer Graphics Terminals
Contact: Lee Blazer 503/682-3411

Teletype Corporation
5555 Touhy Avenue
Skokie, IL 60076
Tempest Terminals
312/982-2000

Terminal Data Corporation
21221 Oxnard Street
Woodland Hills, CA 91367
Documate II/Intelmate 1010
Contact: Sam Greene 213/887-4900

3M Company
St. Paul, Minn. 55105
Computer-Output-Microfilm systems, sale, services and supplies
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Zeta Research
2300 Stanwell Drive
Concord, CA 94520
Zeta 6300 plotting system
Contact: Gary Hasenfus 415/671-0600

EDP For ABC's

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academically successful children and certainly help them learn.

Significantly, the PLATO experience has shown that the dichotomy is not always that great between youths needing remediation and the gifted. As an example, John L. Martin, now a senior, was referred to the PLATO system as a failing student a couple of years ago. He is now an outstanding scholar, studying computer programming, helping develop programs and assisting CDC representatives in demonstrating the Basic Skills programs to educators in other cities.

At Walbrook High School we use many means to challenge students and motivate them to achieve here so they can meet the challenges of college and/or the world of work. The PLATO system is just one of those means, and it has been uniquely successful in helping students make quantum strides in basic mathematics and reading. Mastering those vital areas is essential if our young people are going to succeed in life, no matter what yardstick we use for success.

Ad Index

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